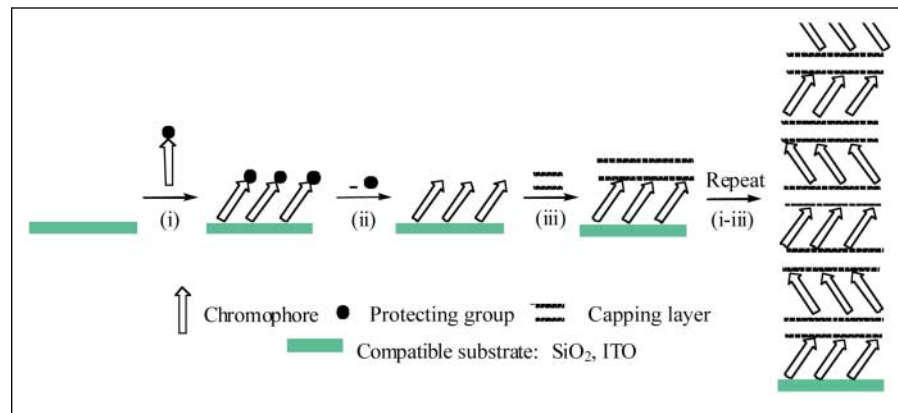


### Self-Assembly of Organic/ Inorganic Superlattice Structures May Enable Novel Photonic Devices

Novel organic-based electro-optic (EO) components have the potential to greatly increase the rates of information transmission. The preparation of an organic EO superlattice consisting of layers of chromophore molecules separated by polysiloxane films was recently reported by M.E. van der Boom and T.J. Marks of Northwestern University and their colleagues both at Northwestern and the University of Arizona. The intrinsically acentric superlattice was prepared by a simple and efficient "one-pot" wet chemical self-assembly procedure and exhibited high structural regularity and excellent EO response properties. The researchers said that the material, synthetic method, and nanoscale control of the fabrication may contribute to a simplified method of macroscopic device fabrication.

As communicated in the January issue of *Chemistry of Materials*, the superlattice was prepared by allowing a layer of chromophore molecules to chemisorb onto a hydrophilic substrate, chemically de-protecting the chromophore film, and growing a thin polysiloxane layer ( $-\text{SiO}_2-$ ) which is capable of covalently binding another layer of chromophore molecules. The researchers used the known chromophore 4-[[4-[N,N-(*tert*-butyldimethylsiloxy)ethyl]amino]phenyl]azo]pyridine, which was modified with an *n*-propyl-3-trimethoxysilane functionality to allow strong covalent binding to silicon, glass, or indium tin oxide (ITO)-coated glass substrates. The chromophore layer was then treated with *n*- $\text{Bu}_4\text{NF}$  to remove the *t*-butyldimethylsilyl protecting groups, resulting in a large density of reactive surface hydroxyl sites. The de-protected chromophores were treated with a hep-



Schematic representation of iterative self-assembly of acentric organic/inorganic superlattice structures. Reproduced with permission from *Chem. Mater.* **13** (2001) p. 16. Copyright 2001 American Chemical Society.

tane solution of octachlorotrisiloxane, which cross-linked and capped the chromophores with a robust polysiloxane film. The formation of this film enhances the stability and planarity of the structure. The hydrophilic polysiloxane layer was then exposed again to a chromophore solution, and the process was repeated until the desired number of layers had been deposited. The researchers reported the synthesis of superlattices having up to six bilayers. Each bilayer was determined to be  $\sim 20$  Å thick. (See Figure.)

Characterization of the superlattice by synchrotron x-ray reflectivity and optical (UV-visible) spectroscopy showed that equal densities of chromophores are deposited in each layer and that the chromophore orientations are uniform. Second harmonic generation measurements revealed that the chromophores have a uniform polar alignment and structural regularity. The high structural regularity was further confirmed by atomic force microscopy on a six-bilayer assembly that indicated that the surface is smooth and featureless, with less than 8% roughness. The lattices were found to be thermally and photochemically robust and exhibited a very large EO response.

According to the researchers, this self-assembly approach is applicable to other chromophores and is more efficient than existing synthetic routes to EO materials. The fact that the entire preparation can be carried out in one reaction vessel makes this approach easily adaptable to automation. Furthermore, the layer-by-layer modularity of self-assembled superlattice building-block incorporation raises the intriguing question of whether other functional constituents (e.g., optical, elec-

tronic, magnetic, and mechanical) could be intercalated as part of the self-assembly process. The strong binding of the modified chromophores to silicon, glass, and ITO allows ready integration of these structurally tailored photonically/electronically functional materials into novel electro-optic devices.

GREGORY KHITROV

### Potential Utility of Multiwalled Carbon Nanotube Field-Effect Transistors as Environmental Sensors Demonstrated

In the study of carbon nanotubes (NTs) as field-effect transistors (FETs), the silicon substrate usually also serves as the gate. However, with this method only weak field effects were observed in multiwalled nanotubes (MWNTs). Recently, collaborators at Universität Basel and École Polytechnique Fédérale de Lausanne in Switzerland have experimented with a new gating method, *electrochemical gating*, on a single MWNT. This method yields a much higher transconductance (gate-induced change on the electrical resistance) than the usual substrate back gating (BG) on MWNTs and demonstrates the extreme sensitivity of the MWNT FET to its surrounding environment—in this case, different electrolytes.

The researchers used single MWNTs with lithographically defined Au contacts evaporated over the NTs, fabricated on degenerately doped Si with a 400-nm-thick SiO<sub>2</sub> spacer layer. They positioned a micropipet over the device to deliver a LiClO<sub>4</sub> electrolyte droplet of a diameter  $\leq 100$  μm, thereby immersing the NT into the electrolyte. They used a Pt wire within the glass pipet as the gate contact, and

#### SBIR Update

**MATECH Advanced Materials** (Westlake Village, California) has been awarded a Phase I SBIR grant from the U.S. National Science Foundation to develop a new class of photocurable preceramic polymers to silicon nitride, an advanced ceramic material.

**Powdermet, Inc.** (Sun Valley, California) has been granted a six-month Phase I SBIR contract from the Department of Energy to further develop nanoengineered, oxide-dispersion-strengthened iron aluminate powders.